SciKGTeX:
A LaTeX Package for FAIR-Annotated Publications

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Leibniz Association

# Problem: Making Publications FAIR is a Downstream Task

Problem: ORKG focuses on **published** articles, so making them **FAIR** is a **downstream task** and often **not done by the author**.
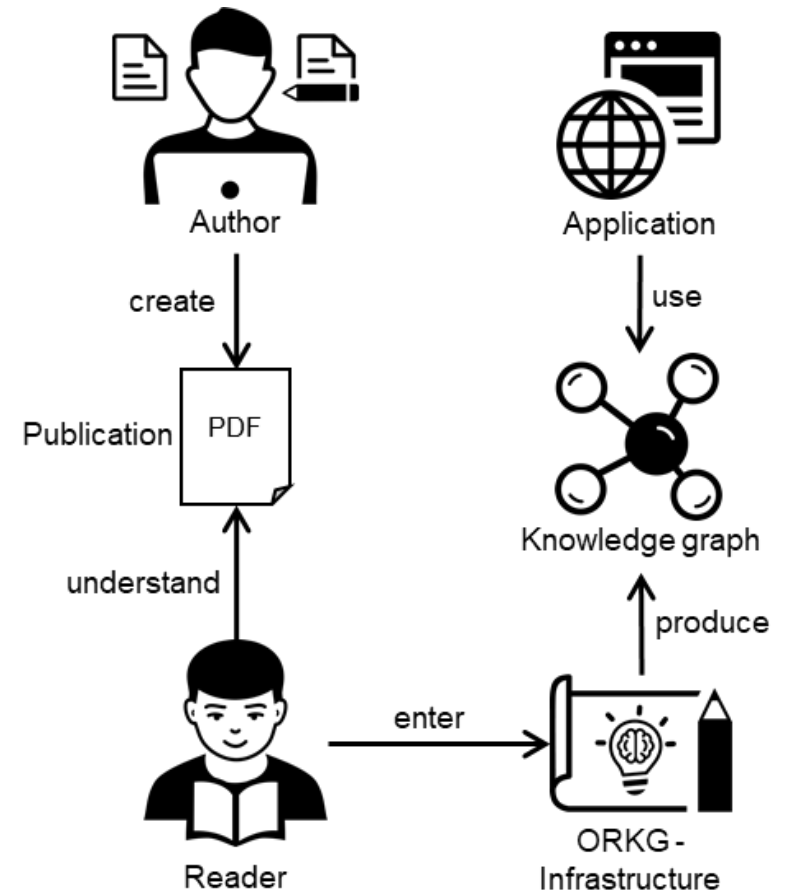
Solution: "FAIR-by-Design" Artifacts and SciKGTeX[8]

Solution: "FAIR-by-Design" Artifacts.
SciKGTeX supports authors in making their publication **FAIR** at the time of **creation**.

- **Authors describe** their publication with FAIR information **only once** and **in parallel** at the time of **creation**

- **SciKGTeX embeds** FAIR information **into** the **PDF metadata** as a knowledge graph
  - **Persistent** over PDF lifetime
  - **Available** for anyone
  - **Reusable**, e.g., import into ORKG
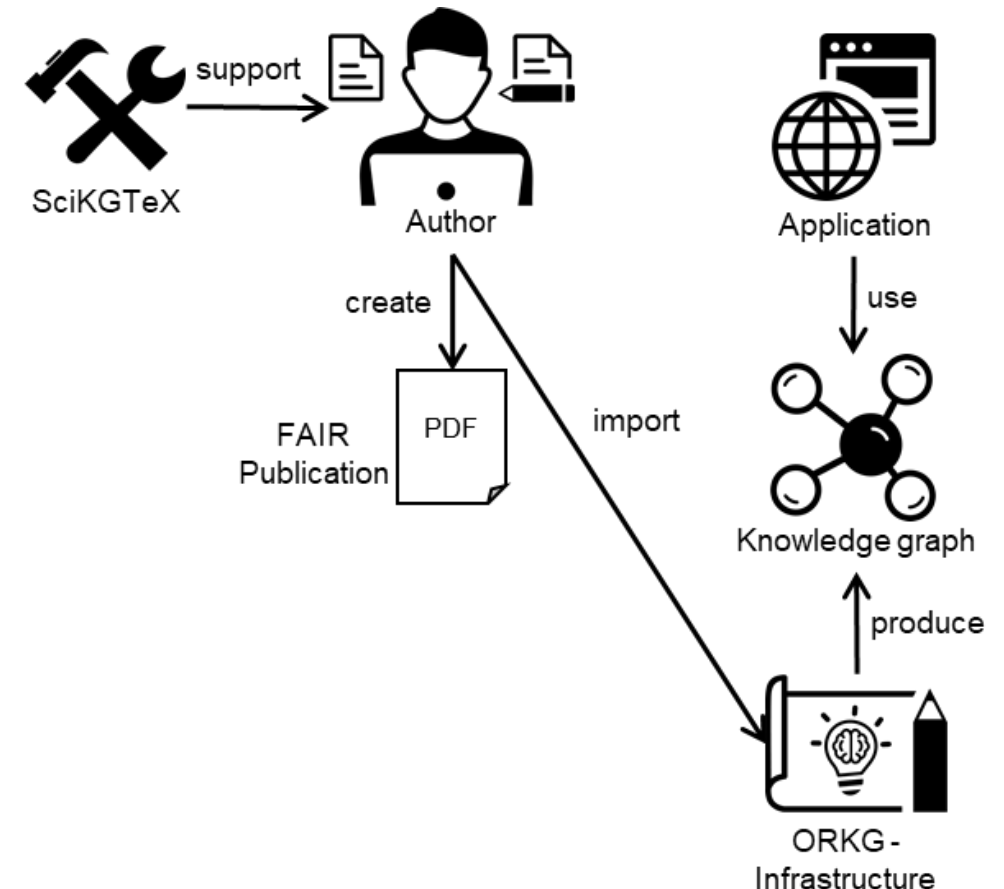
[8] Bless et al.: *SciKGTeX – A LaTeX Package to Semantically Annotate Contributions in Scientific Publications.* 2023 ACM/IEEE Joint Conference on Digital Libraries (JCDL), DOI: 10.1109/JCDL57899.2023.00030, 2023.

Promotion of Open Science in Requirements Engineering – Leveraging the Open Research Knowledge Graph for FAIR Scientific Information

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SciKGTeX – Scientific Knowledge Graph TeX

- Predefined commands for annotation
  - 3 commands for metadata
    - Title
    - Author
    - Research field
  - 5 commands for content
    - Research problem
    - Objective
    - Method
    - Result
    - Conclusion

- Support for own custom annotations
  - REFSQ'24 and REFSQ'25 ask for
    - Code repository
    - Dataset

```
\usepackage{scikgtex}

\begin{document}

The role of \researchproblem{antibiotic therapy} is controversial.
The purpose of this study was to \objective{determine the
effectiveness of high-dose amoxicillin/potassium clavulanate in the
treatment of children}.
This was a \method{randomized, double-blind, placebo-controlled
study}.
\result{Children receiving the antibiotic were more likely to be
cured (50% vs 14%) than children receiving the placebo}.
\conclusion{Amoxicillin/potassium clavulanate results in
significantly more cures and fewer failures than placebo}.

\end{document}
```
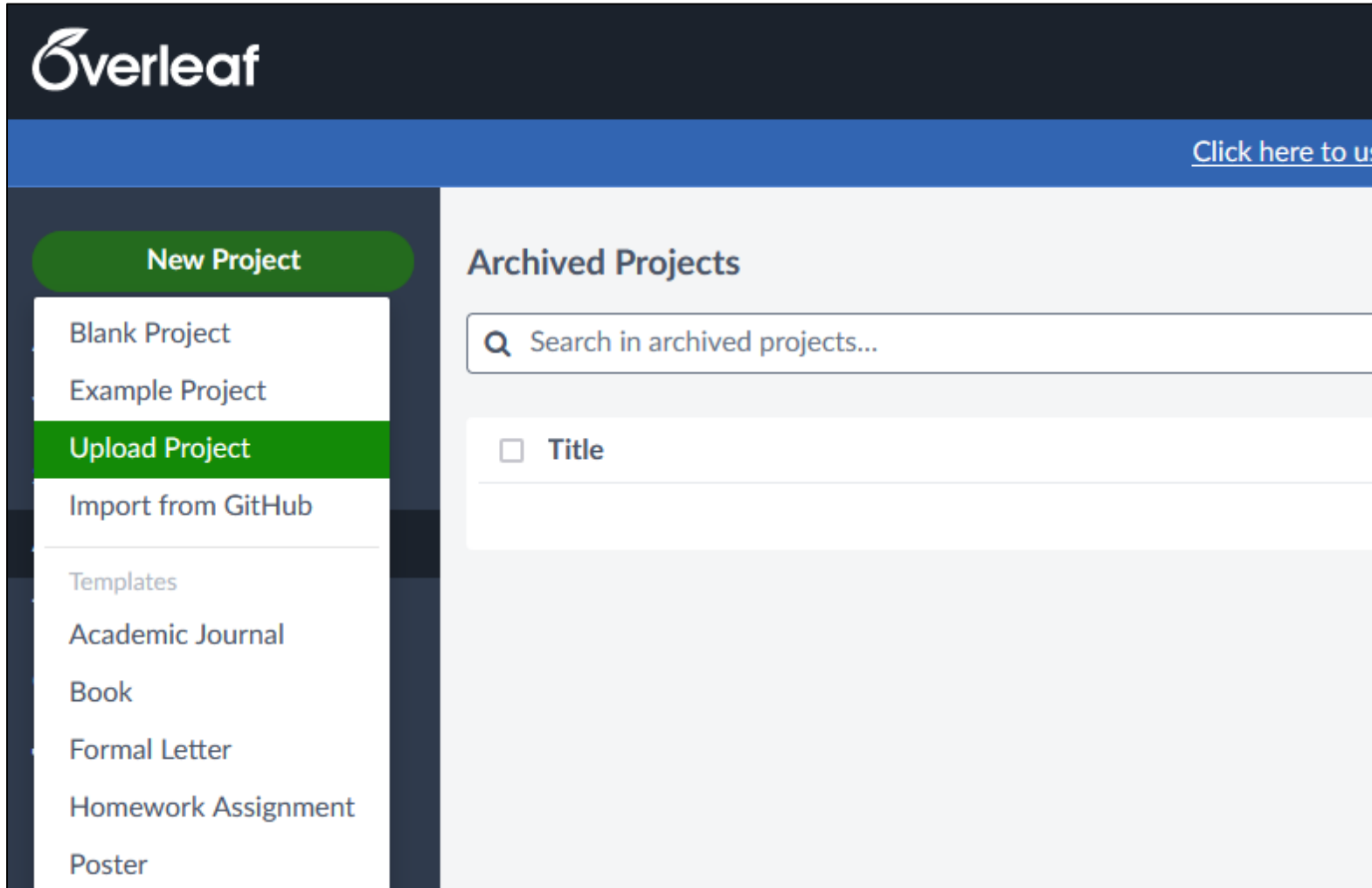
Complete documentation and latest version:
https://github.com/Christof93/SciKGTeX

Set up a LaTeX Project (using Overleaf)

1. Download Example.zip

https://bit.ly/49RjRbO

2. Open Overleaf

https://www.overleaf.com/

3. Upload Example.zip

New Project → Upload Project

4. Select or drag zip file

Remark:
We only use an abstract for the annotations as a simplified example. Annotations can be used **anywhere** (in one or more LaTeX files).

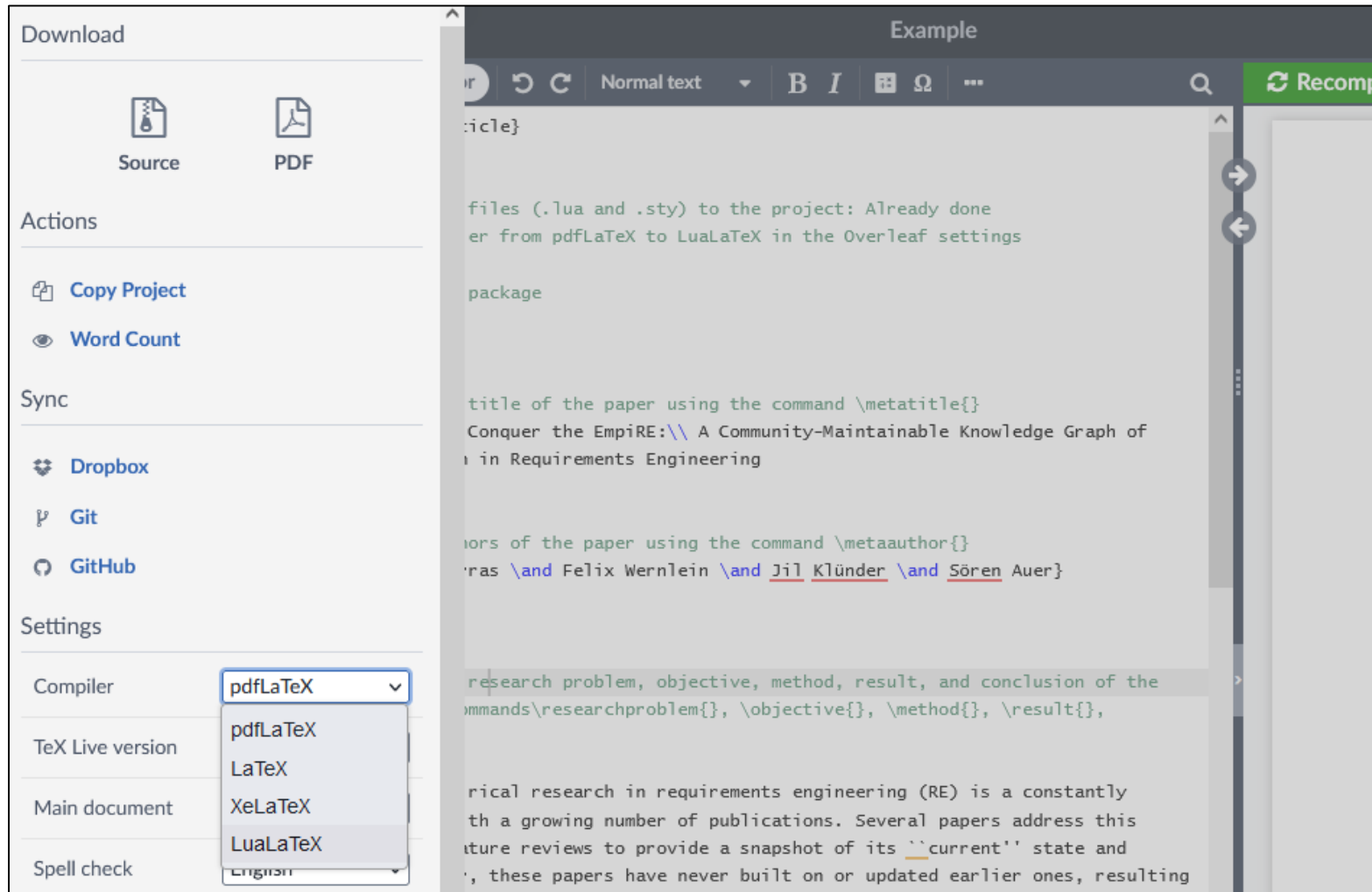# 0. Add SciKGTeX Files to the Project

The following two files must be present:

- scikgtex.lua
- scikgtex.sty

1. Change Complier from pdfLaTeX to LuaLaTeX

It is necessary to compile your LaTeX source with **LuaLaTeX** for the SciKGTeX package to work.

2. Add the SciKGTeX Package to the LaTeX File

```
1   \documentclass{article}
2   \usepackage{url}
3
4   % 0. Add scikgtex files (.lua and .sty) to the project: Already done
5   % 1. Change compiler from pdfLaTeX to LuaLaTeX in the Overleaf settings
6
7   % 2. Add SciKGTeX package
8
9
10  \begin{document}
11
```

Add the command to the preamble of the LaTeX file:

\usepackage{scikgtex}

2. Add the SciKGTeX Package to the LaTeX File: Result

```
1   \documentclass{article}
2   \usepackage{url}
3
4   % 0. Add scikgtex files (.lua and .sty) to the project: Already done
5   % 1. Change compiler from pdfLaTeX to LuaLaTeX in the Overleaf settings
6
7   % 2. Add SciKGTeX package
8   \usepackage{scikgtex}
9
10  \begin{document}
11
```

Add the command to the preamble of the LaTeX file:

\usepackage{scikgtex}

3. & 4. Annotate Metadata of the Paper

```
10 ▾  \begin{document}
11
12    % 3. Annotate the title of the paper using the command \metatitle{}
13 ▾  \title{Divide and Conquer the EmpiRE:\\ A Community-Maintainable Knowledge Graph of
      Empirical Research in Requirements Engineering
14    }
15
16    % 4. Annotate authors of the paper using the command \metaauthor{}
17    \author{Oliver Karras \and Felix Wernlein \and Jil Klünder \and Sören Auer}
18
19    \maketitle
20
```

1. Annotate the title

\metatitle{}

2. Annotate the authors

\metaauthor{}

Remark:
The command \metaauthor{} must be used individually **for each author**. With four authors, you need the command four times.

3. & 4. Annotate Metadata of the Paper: Result

```
10  \begin{document}
11
12  % 3. Annotate the title of the paper using the command \metatitle{}
13  \title{\metatitle{Divide and Conquer the EmpiRE:\\ A Community-Maintainable Knowledge
       Graph of Empirical Research in Requirements Engineering}
14  }
15
16  % 4. Annotate authors of the paper using the command \metaauthor{}
17  \author{\metaauthor{Oliver Karras} \and \metaauthor{Felix Wernlein} \and
       \metaauthor{Jil Klünder} \and \metaauthor{Sören Auer}}
18
19  \maketitle
20
```

1. Annotate the title

\metatitle{}

2. Annotate the authors

\metaauthor{}

Remark:
The command \metaauthor{} must be used individually **for each author**. With four authors, you need the command four times.

5. Annotate Content of the Paper

```
21  % 5. Annotate the research problem, objective, method, result, and conclusion of the
    paper using the commands\researchproblem{}, \objective{}, \method{}, \result{},
    \conclusion{}
22  \begin{abstract}
23  [Background.] Empirical research in requirements engineering (RE) is a constantly
    evolving topic, with a growing number of publications. Several papers address this
    topic using literature reviews to provide a snapshot of its ``current'' state and
    evolution. However, these papers have never built on or updated earlier ones, resulting
    in overlap and redundancy. The underlying problem is the unavailability of data from
    earlier works. Researchers need technical infrastructures to conduct sustainable
    literature reviews. [Aims.] We examine the use of the Open Research Knowledge Graph
    (ORKG) as such an infrastructure to build and publish an initial Knowledge Graph of
    Empirical research in RE (KG-EmpiRE) whose data is openly available. Our long-term goal
    is to continuously maintain KG-EmpiRE with the research community to synthesize a
    comprehensive, up-to-date, and long-term available overview of the state and evolution
    of empirical research in RE. [Method.] We conduct a literature review using the ORKG to
    build and publish KG-EmpiRE which we evaluate against competency questions derived from
    a published vision of empirical research in software (requirements) engineering for
    2020 -- 2025. [Results.] From 570 papers of the IEEE International Requirements
    Engineering Conference (2000 -- 2022), we extract and analyze data on the reported
    empirical research and answer 16 out of 77 competency questions. These answers show a
    positive development towards the vision, but also the need for future improvements.
    [Conclusions.] The ORKG is a ready-to-use and advanced infrastructure to organize data
    from literature reviews as knowledge graphs. The resulting knowledge graphs make the
    data openly available and maintainable by research communities, enabling sustainable
    literature reviews.
24  \end{abstract}
```

1. Annotate the research problem

   \researchproblem{}

2. Annotate the objective

   \objective{}

3. Annotate the method

   \method{}

4. Annotate the result

   \result{}

5. Annotate the conclusion

   \conclusion{}

5. Annotate Content of the Paper

```
21   % 5. Annotate the research problem, objective, method, result, and conclusion of the
```

Remark:
- All commands can be used **multiple** times.
- The annotated text elements should be as **short** as **possible** and as **long** as **necessary**.
- Definitions:
  - **Research problem**: Issue or gap in existing knowledge addressed by the paper.
  - **Objective**: Goal that the paper aims to achieve.
  - **Method**: Systematic approach, technique, or action plan used in the paper to achieve a goal and result.
  - **Result**: Outcome from a systematic approach, technique, or action plan used in the paper.
  - **Conclusion**: Findings from the analysis of the research results in the paper.

```
24   \end{abstract}
```

1. Annotate the research problem

\researchproblem{}

2. Annotate the objective

\objective{}

3. Annotate the method

\method{}

4. Annotate the result

\result{}

5. Annotate the conclusion

\conclusion{}

5. Annotate Content of the Paper: Result

```latex
21  % 5. Annotate the research problem, objective, method, result, and conclusion of the
    paper using the commands\researchproblem{}, \objective{}, \method{}, \result{},
    \conclusion{}
22  \begin{abstract}
23  [Background.] Empirical research in requirements engineering (RE) is a constantly
    evolving topic, with a growing number of publications. Several papers address this
    topic using literature reviews to provide a snapshot of its ``current'' state and
    evolution. However, these papers have never built on or updated earlier ones, resulting
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    [Method.] We conduct a \method{literature review using the ORKG} to build and publish
    KG-EmpiRE which we \method{evaluate against competency questions} derived from a
    published vision of empirical research in software (requirements) engineering for 2020
    -- 2025. [Results.] \result{From 570 papers of the IEEE International Requirements
    Engineering Conference (2000 -- 2022), we extract and analyze data on the reported
    empirical research} and \result{answer 16 out of 77 competency questions}. These
    answers show a positive development towards the vision, but also the need for future
    improvements. [Conclusions.] \conclusion{The ORKG is a ready-to-use and advanced
    infrastructure to organize data from literature reviews as knowledge graphs}. The
    resulting knowledge graphs make the data openly available and maintainable by research
    communities, enabling sustainable literature reviews.
24  \end{abstract}
```

1. Annotate the research problem

\researchproblem{}

2. Annotate the objective

\objective{}

3. Annotate the method

\method{}

4. Annotate the result

\result{}

5. Annotate the conclusion

\conclusion{}

6. Annotate Content of the Paper with Invisible Markup

```
21  % 5. Annotate the research problem, objective, method, result, and conclusion of the
    paper using the commands\researchproblem{}, \objective{}, \method{}, \result{},
    \conclusion{}
22  \begin{abstract}
23  [Background.] Empirical research in requirements engineering (RE) is a constantly
    evolving topic, with a growing number of publications. Several papers address this
    topic using literature reviews to provide a snapshot of its ``current'' state and
    evolution. However, these papers have never built on or updated earlier ones, resulting
    in overlap and redundancy. The underlying problem is the
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    infrastructures to conduct sustainable literature reviews. [Aims.] We examine the
    \objective{use of the Open Research Knowledge Graph (ORKG) as such an infrastructure to
    build and publish an initial Knowledge Graph of Empirical research in RE (KG-EmpiRE)
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    EmpiRE with the research community to synthesize a comprehensive, up-to-date, and long-
    term available overview of the state and evolution of empirical research in RE.
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    KG-EmpiRE which we \method{evaluate against competency questions} derived from a
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    -- 2025. [Results.] \result{From 570 papers of the IEEE International Requirements
    Engineering Conference (2000 -- 2022), we extract and analyze data on the reported
    empirical research} and \result{answer 16 out of 77 competency questions}. These
    answers show a positive development towards the vision, but also the need for future
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    infrastructure to organize data from literature reviews as knowledge graphs}. The
    resulting knowledge graphs make the data openly available and maintainable by research
    communities, enabling sustainable literature reviews.
24  \end{abstract}
```

What can I do, if the text is not suitable for annotation?

Example:

"… \method{evaluate against competency questions} …"

Solution:

\method*{evaluation against competency questions}

> **Remark:**
> This text is added to the PDF metadata, but **not rendered** in the text of the PDF.

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6. Annotate Content of the Paper with Invisible Markup: Result

```
21  % 5. Annotate the research problem, objective, method, result, and conclusion of the
    paper using the commands\researchproblem{}, \objective{}, \method{}, \result{},
    \conclusion{}
22  \begin{abstract}
23  [Background.] Empirical research in requirements engineering (RE) is a constantly
    evolving topic, with a growing number of publications. Several papers address this
    topic using literature reviews to provide a snapshot of its ``current'' state and
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    Knowledge Graph (ORKG) as such an infrastructure to build and publish an initial
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    of the state and evolution of empirical research in RE. [Method.] We conduct a
    \method{literature review using the ORKG to build and publish KG-EmpiRE which we
    evaluate against competency questions derived from a published vision of empirical
    research in software (requirements) engineering for 2020 -- 2025. [Results.]
    \result{From 570 papers of the IEEE International Requirements Engineering Conference
    (2000 -- 2022), we extract and analyze data on the reported empirical research} and
    \result{answer 16 out of 77 competency questions}. These answers show a positive
    development towards the vision, but also the need for future improvements.
    [Conclusions.] \conclusion{The ORKG is a ready-to-use and advanced infrastructure to
    organize data from literature reviews as knowledge graphs}. The resulting knowledge
    graphs make the data openly available and maintainable by research communities,
    enabling sustainable literature reviews.
24  \end{abstract}
25
26  % 6. If written text is not suitable for annotation, we can also annotate invisible
    text using the *-notation
27  \researchproblem*{unavailability of the extracted and analyzed data from literature
    reviews}
28  \method*{evaluation against competency questions}
```

What can I do, if the text is not suitable for annotation?

Example:

"… \method{evaluate against competency questions} …"

Solution:

\method*{evaluation against competency questions}

Remark:
This text is added to the PDF metadata, but **not rendered** in the text of the PDF.

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Comparison of Annotated Paper Versions

```
21  % 5. Annotate the research problem, objective, method, result, and conclusion of the
    paper using the commands\researchproblem{}, \objective{}, \method{}, \result{},
    \conclusion{}
22  \begin{abstract}
23  [Background.] Empirical research in requirements engineering (RE) is a constantly
    evolving topic, with a growing number of publications. Several papers address this
    topic using literature reviews to provide a snapshot of its ``current'' state and
    evolution. However, these papers have never built on or updated earlier ones, resulting
    in overlap and redundancy. The underlying problem is the
    \researchproblem{unavailability of data from earlier works}. Researchers need technical
    infrastructures to conduct sustainable literature reviews. [Aims.] We examine the
    \objective{use of the Open Research Knowledge Graph (ORKG) as such an infrastructure to
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    whose data is openly available}. Our long-term goal is to continuously maintain KG-
    EmpiRE with the research community to synthesize a comprehensive, up-to-date, and long-
    term available overview of the state and evolution of empirical research in RE.
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    KG-EmpiRE which we \method{evaluate against competency questions} derived from a
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    Engineering Conference (2000 -- 2022), we extract and analyze data on the reported
    empirical research} and \result{answer 16 out of 77 competency questions}. These
    answers show a positive development towards the vision, but also the need for future
    improvements. [Conclusions.] \conclusion{The ORKG is a ready-to-use and advanced
    infrastructure to organize data from literature reviews as knowledge graphs}. The
    resulting knowledge graphs make the data openly available and maintainable by research
    communities, enabling sustainable literature reviews.
24  \end{abstract}
```

```
21  % 5. Annotate the research problem, objective, method, result, and conclusion of the
    paper using the commands\researchproblem{}, \objective{}, \method{}, \result{},
    \conclusion{}
22  \begin{abstract}
23  [Background.] Empirical research in requirements engineering (RE) is a constantly
    evolving topic, with a growing number of publications. Several papers address this
    topic using literature reviews to provide a snapshot of its ``current'' state and
    evolution. However, these papers have never built on or updated earlier ones, resulting
    in overlap and redundancy. The underlying problem is the unavailability of data from
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    Knowledge Graph (ORKG) as such an infrastructure to build and publish an initial
    Knowledge Graph of Empirical research in RE (KG-EmpiRE) whose data is openly
    available}. Our long-term goal is to continuously maintain KG-EmpiRE with the research
    community to synthesize a comprehensive, up-to-date, and long-term available overview
    of the state and evolution of empirical research in RE. [Method.] We conduct a
    \method{literature review using the ORKG} to build and publish KG-EmpiRE which we
    evaluate against competency questions derived from a published vision of empirical
    research in software (requirements) engineering for 2020 -- 2025. [Results.]
    \result{From 570 papers of the IEEE International Requirements Engineering Conference
    (2000 -- 2022), we extract and analyze data on the reported empirical research} and
    \result{answer 16 out of 77 competency questions}. These answers show a positive
    development towards the vision, but also the need for future improvements.
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    organize data from literature reviews as knowledge graphs}. The resulting knowledge
    graphs make the data openly available and maintainable by research communities,
    enabling sustainable literature reviews.
24  \end{abstract}
25
26  % 6. If written text is not suitable for annotation, we can also annotate invisible
    text using the *-notation
27  \researchproblem*{unavailability of the extracted and analyzed data from literature
    reviews}
28  \method*{evaluation against competency questions}
```

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7. (Optional) Annotate Research Field

Remark:
1. A paper in the ORKG is assigned to a research field based on the DFG classification. All research fields: https://orkg.org/fields.
2. URI of the ORKG semantic web resource for Software Engineering: https://orkg.org/resource/R140.
3. Use the command \uri{"**URI**"}{"**Label**"} inside an annotation to refer to resources in the semantic web. The first argument is the **URI** to the semantic resource and the second is an optional **Label**.
4. The term "Software Engineering" does not appear in the abstract, so we need an **invisible** annotation and we also use the \uri{}{} command to create a reference to the semantic resource.

1. Annotate the research field

\researchfield{}

2. Refer to the ORKG semantic web resource Software Engineering

\uri{"URI"}{"Label"}

7. (Optional) Annotate Research Field: Result

```
29    % 7. Optional: Annotate research field of the paper
30    \researchfield*{\uri{https://orkg.org/resource/R140}{Software Engineering}}
```

Remark:
1. A paper in the ORKG is assigned to a research field based on the DFG classification. All research fields: https://orkg.org/fields.
2. URI of the ORKG semantic web resource for Software Engineering: https://orkg.org/resource/R140.
3. Use the command \uri{"**URI**"}{"**Label**"} inside an annotation to refer to resources in the semantic web. The first argument is the **URI** to the semantic resource and the second is an optional **Label**.
4. The term "Software Engineering" does not appear in the abstract, so we need an **invisible** annotation and we also use the \uri{}{} command to create a reference to the semantic resource.

1. Annotate the research field

\researchfield{}

2. Refer to the ORKG semantic web resource Software Engineering

\uri{"URI"}{"Label"}

8. Use Custom Annotations of REFSQ'24 and REFSQ'25

```
33  % 8. Optional: Using REFSQ'24 and REFSQ'25 annotations
34  \contribution*{code repository}{\url{https://github.com/okarras/EmpiRE-Analysis}}
35  \contribution*{dataset}{\url{https://orkg.org/api/rdf/dump}}
36
37  \end{document}
```

1. Annotate the code repository

\contribution{code repository}{}

2. Annotate the dataset

\contribution{dataset}{}

Remark:
1. Use the command \contribution{"**Property name**"}{"**Label**"} to add a custom annotation for your domain. The first argument is the **Property name** of the property from the ORKG you want to use, and the second is an optional **Label**. SciKGTeX checks if a property with the provided exact **Property name** exists and replaces it with the internal property ID in the ORKG namespace.
2. All ORKG properties can be found here: https://orkg.org/properties.

9. Generate FAIR-Annotated PDF of the Paper

Simply…

recompile

Remark:
Each recompile adds the annotations to the metadata of the generated PDF.

9. Generate FAIR-Annotated PDF of the Paper

For the 5 predefined commands for content, SciKGTeX also provides **warnings** if an annotation is missing.

10. Check the FAIR information embedded in the PDF
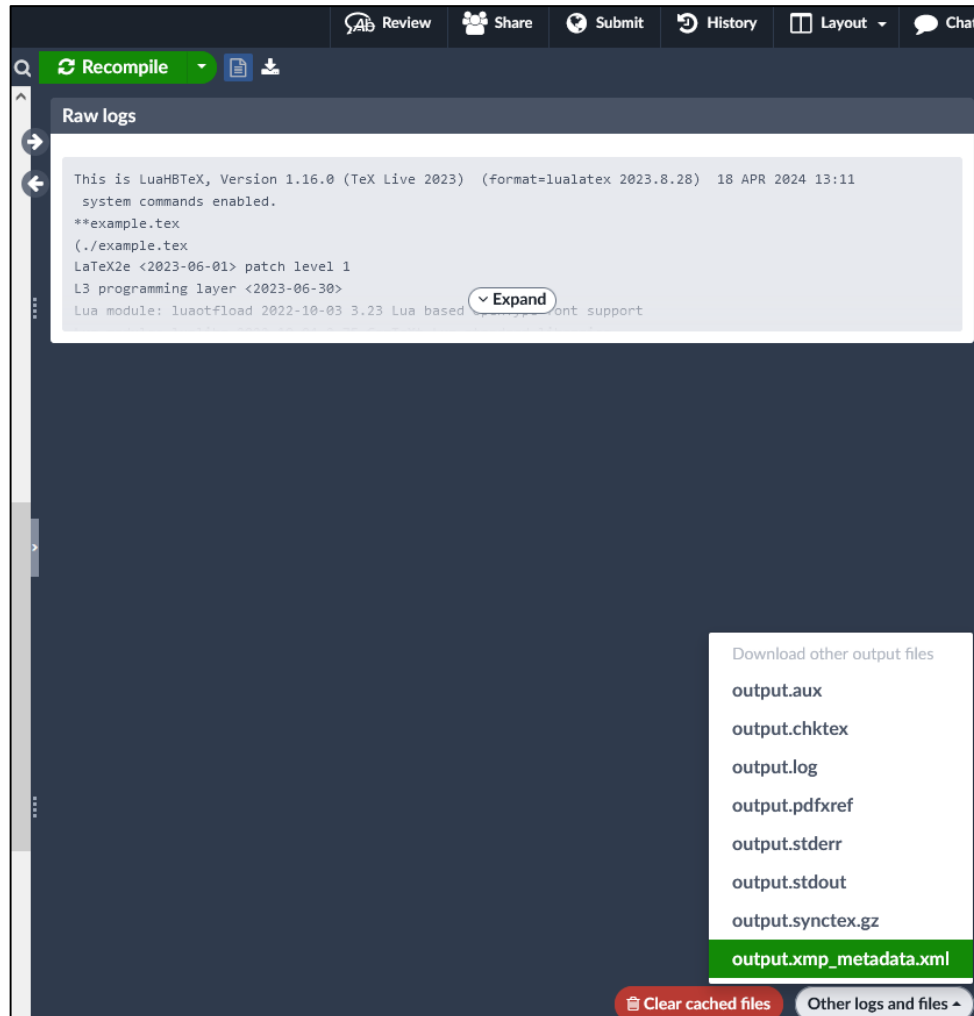
1. Open "Logs and outputs files"

2. Select "Other logs and files"

3. Download "output.xmp_metadata.xml"

4. Open "output.xmp_metadata.xml"

Remark:
We only use an abstract for the annotations as a simplified example. Annotations can be used **anywhere** (in one or more LaTeX files).

10. Check the FAIR information embedded in the PDF

```xml
<?xpacket begin="?" id="a7c48312-233b-400b-c0f3-0c296941c6"?>
<x:xmpmeta xmlns:x="adobe:ns:meta/">
 <rdf:RDF xmlns:orkg="http://orkg.org/core#" xmlns:orkg_property="http://orkg.org/property/" xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
  <rdf:Description rdf:about="https://www.orkg.org/orkg/paper/a7c48312-233b-400b-c0f3-0c296941c6">
    <rdf:type rdf:resource="http://orkg.org/core#Paper"/>
    <orkg:hasTitle>Divide and Conquer the EmpiRE: A Community-Maintainable Knowledge Graph of Empirical Research in Requirements
    Engineering</orkg:hasTitle>
    <orkg:hasAuthor>Oliver Karras</orkg:hasAuthor>
    <orkg:hasAuthor>Felix Wernlein</orkg:hasAuthor>
    <orkg:hasAuthor>Jil Klünder</orkg:hasAuthor>
    <orkg:hasAuthor>Sören Auer</orkg:hasAuthor>
   <orkg_property:P30>
     <rdf:Description rdf:about="https://orkg.org/resource/R140">
       <rdfs:label>Software Engineering</rdfs:label>
     </rdf:Description>
   </orkg_property:P30>
   <orkg:hasResearchContribution>
     <orkg:ResearchContribution rdf:about="https://www.orkg.org/orkg/paper/a7c48312-233b-400b-c0f3-0c296941c6/contribution_ORKG_default">
       <orkg_property:P15051>use of the Open Research Knowledge Graph (ORKG) as such an infrastructure to build and publish an initial Knowledge
       Graph of Empirical research in RE (KG-EmpiRE) whose data is openly available</orkg_property:P15051>
       <orkg_property:P1005>literature review using the ORKG</orkg_property:P1005>
       <orkg_property:P1006>From 570 papers of the IEEE International Requirements Engineering Conference (2000 -- 2022), we extract and analyze
       data on the reported empirical research</orkg_property:P1006>
       <orkg_property:P1006>answer 16 out of 77 competency questions</orkg_property:P1006>
       <orkg_property:P15419>The ORKG is a ready-to-use and advanced infrastructure to organize data from literature reviews as knowledge
       graphs</orkg_property:P15419>
       <orkg_property:P32>unavailability of the extracted and analyzed data from literature reviews</orkg_property:P32>
       <orkg_property:P1005>evaluation against competency questions</orkg_property:P1005>
       <orkg_property:P49000>https://github.com/okarras/EmpiRE-Analysis</orkg_property:P49000>
       <orkg_property:P2005>https://orkg.org/api/rdf/dump</orkg_property:P2005>
     </orkg:ResearchContribution>
   </orkg:hasResearchContribution>
  </rdf:Description>
 </rdf:RDF>
</x:xmpmeta>
<?xpacket end="r"?>
```
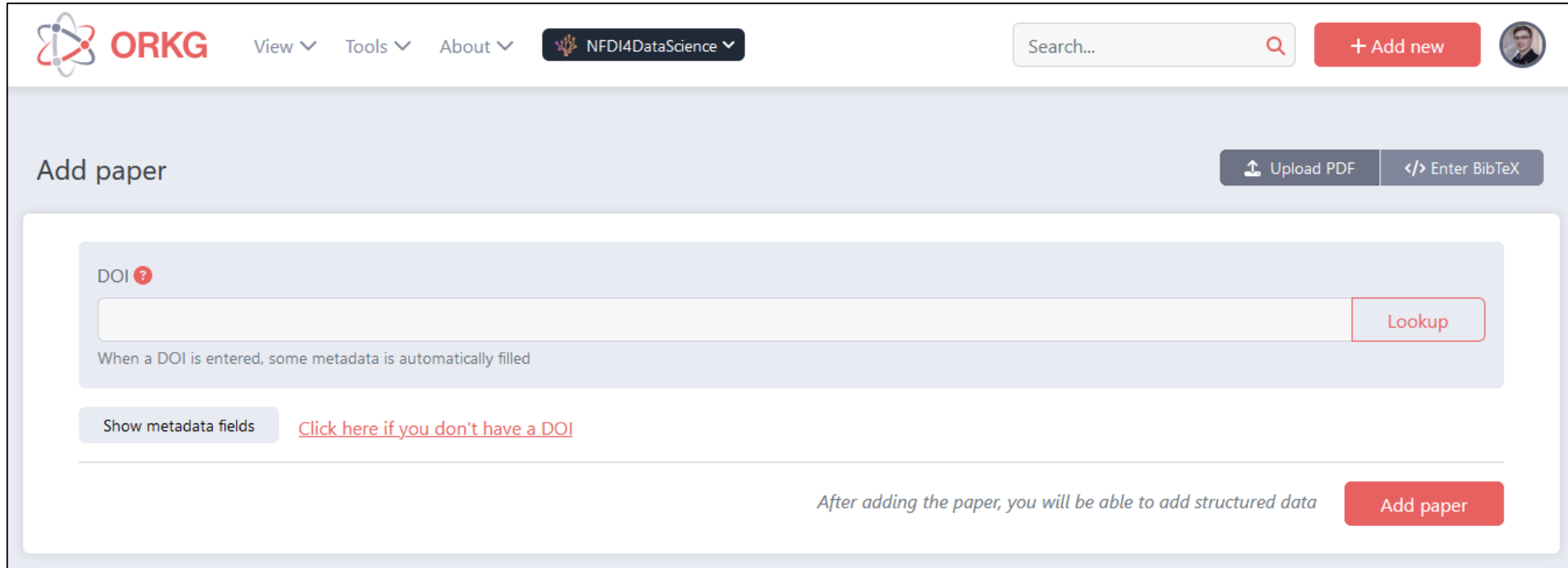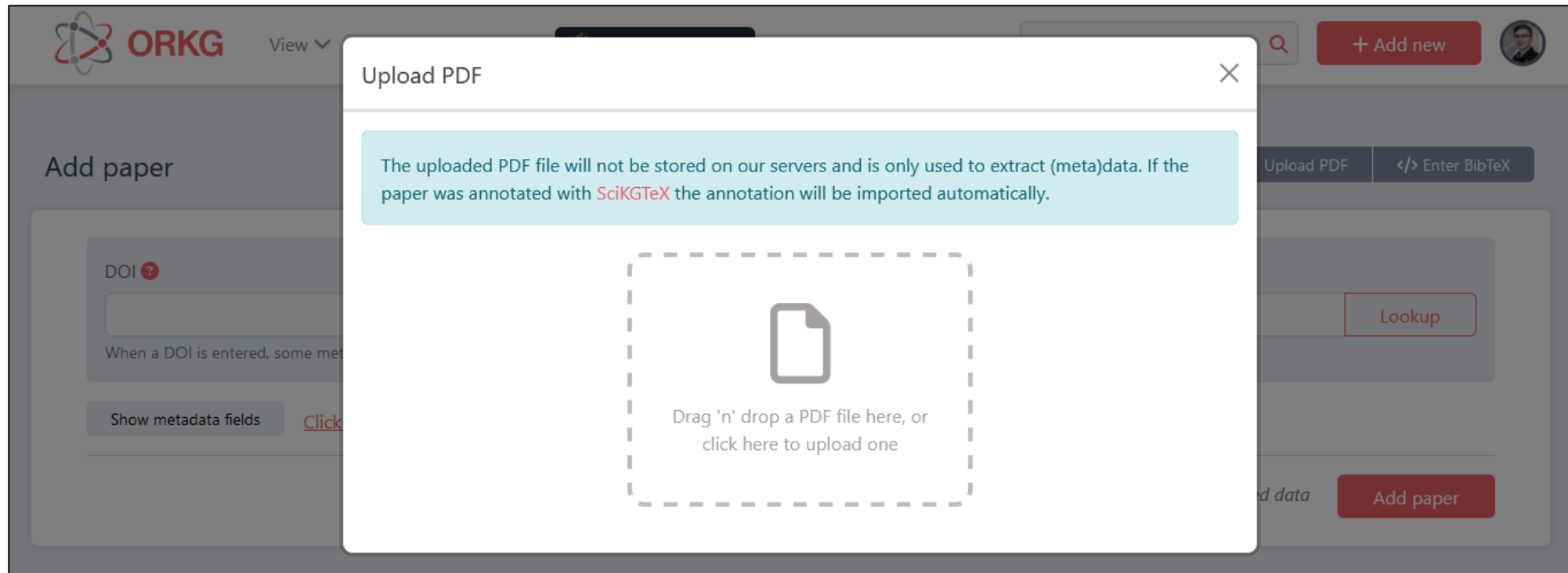
11. Import the FAIR information into the ORKG
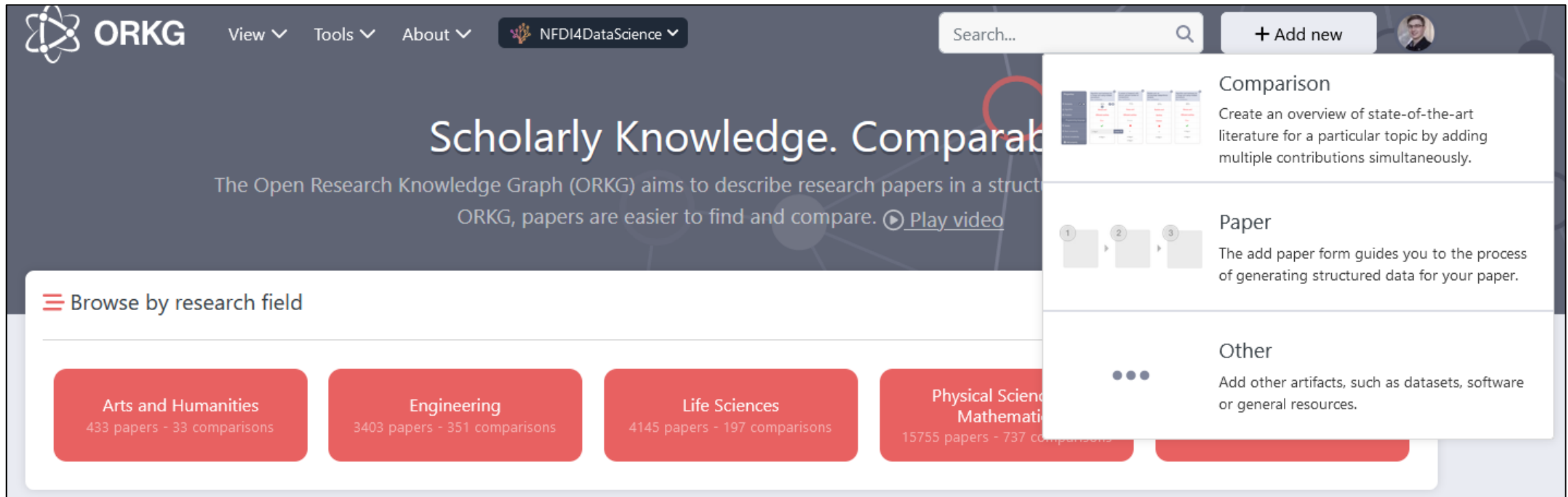
1. Log in with your credentials
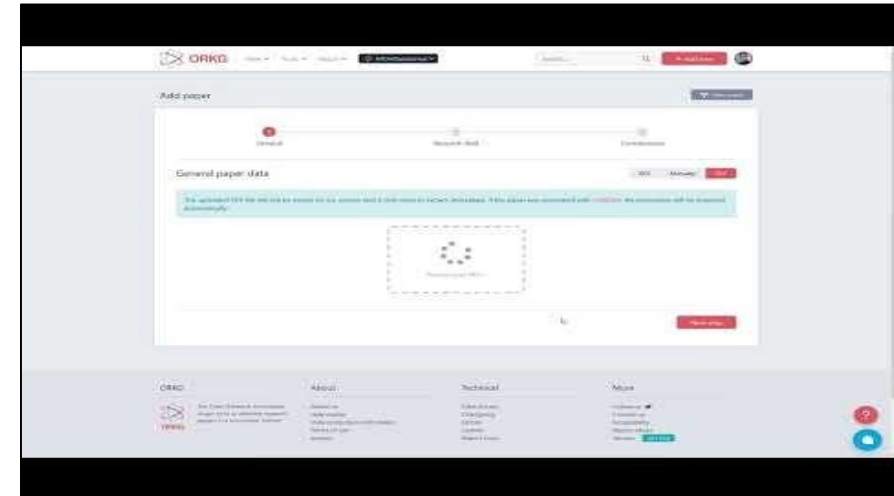2. Click "+ Add new"
3. Select "Paper"

Remark:
ORKG does **not save** the uploaded PDF.
It **only extracts** the FAIR annotations embedded in the PDF metadata.

11. Import the FAIR information into the ORKG

1. Select "Upload PDF"

Remark:
ORKG does **not save** the uploaded PDF.
It **only extracts** the FAIR annotations embedded in the PDF metadata.

11. Import the FAIR information into the ORKG

1. Select or drag your PDF file

Remark:
ORKG does **not save** the uploaded PDF. It **only extracts** the FAIR annotations embedded in the PDF metadata.

11. Import the FAIR information into the ORKG

1. ORKG shows imported metadata

2. Optional: Edit the metadata

3. Select "Add paper" at the bottom

Remark:
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11. Import the FAIR information into the ORKG: Result

https://www.youtube.com/watch?v=ZzrQ_YCKVsYa

Remark:
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